CEAS 2017

Active Flow Separation Control at the Outer Wing
ID 2403

AFLoNext
2ND GENERATION ACTIVE WING

Bucharest, October 18, 2017
Presenter:
Jean-Pierre Rosenblum (Dassault Aviation)

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ACTIVE FLOW SEPARATION CONTROL AT THE OUTER WING (ID 2403)

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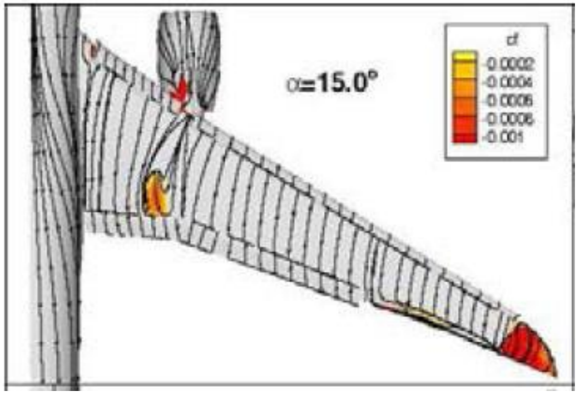
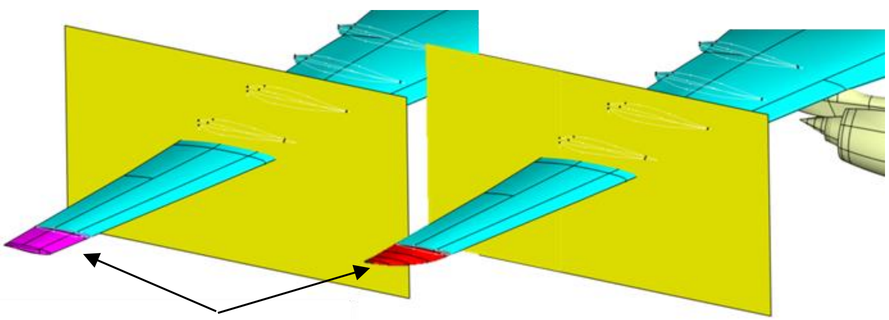
Recall of Active Flow Control objectives



Regions prone to separation
In low speed, high lift conditions

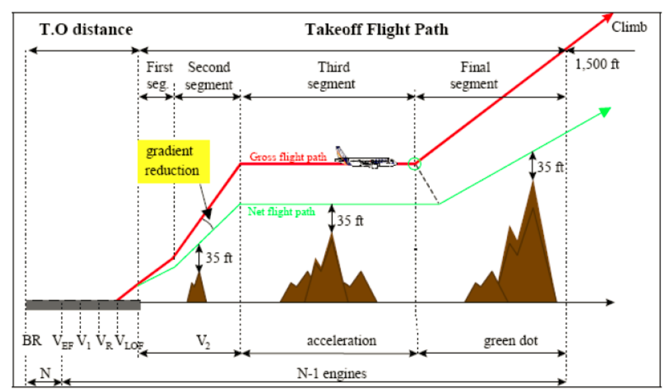
Global objectives:

- See how AFC can help in doing the compromise between low speed and cruise for an aggressive wing tip design.
- The aim is to increase the aerodynamic efficiency of the wing at Take-off by delaying potential flow separation in the outer wing region.
- The use of AFC should help in decreasing the associated drag and increasing L/D, thus leading to a steeper climb gradient in the second segment of climb (when the landing gear is retracted).



wing tip devices

Wing tip devices considered for the study

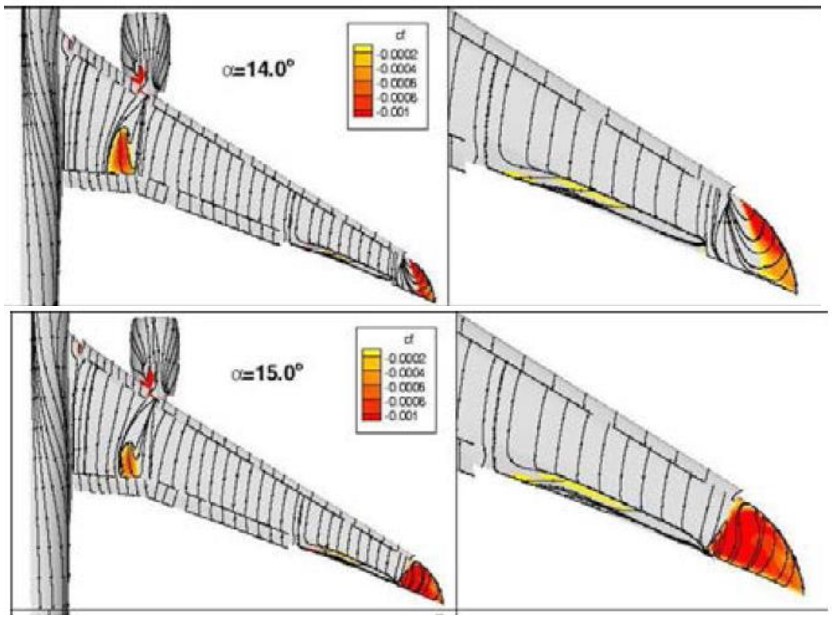


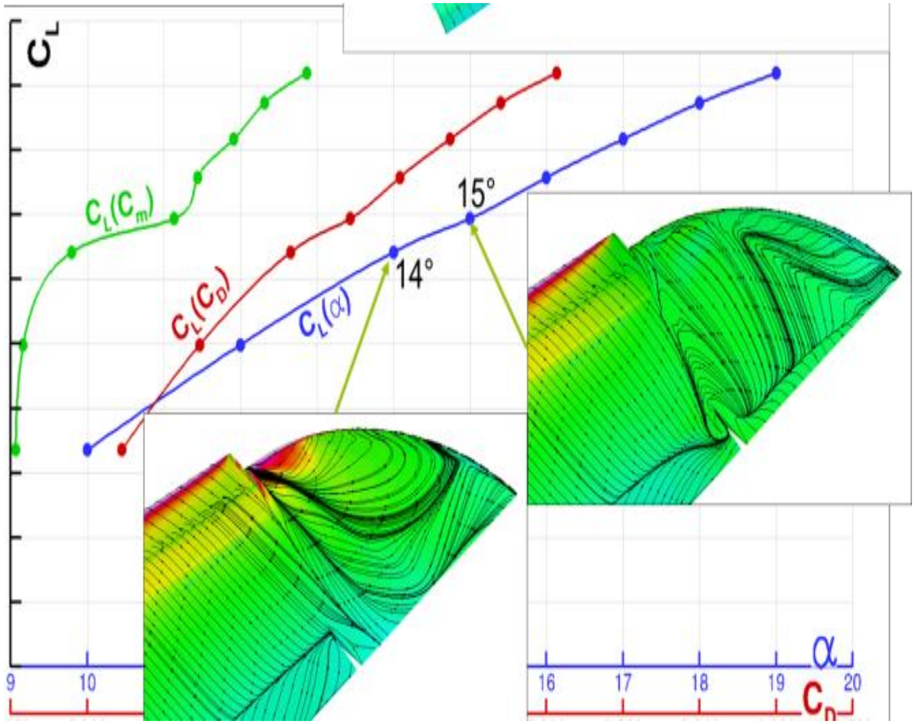
Take-off flight path with one engine inoperative

Baseline aerodynamic characterisation

Wing tip stall identification

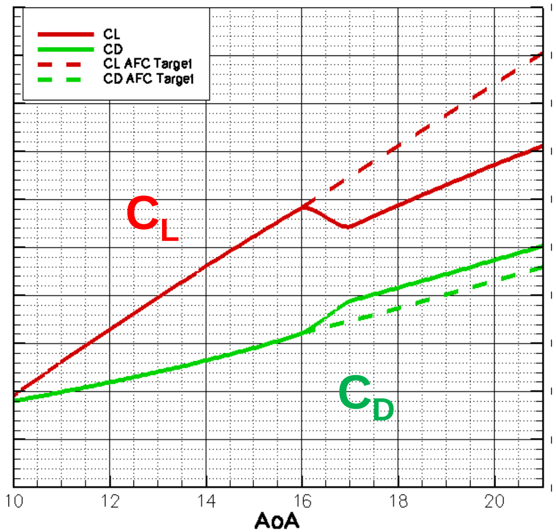
\ Results on Medium and Real geometries

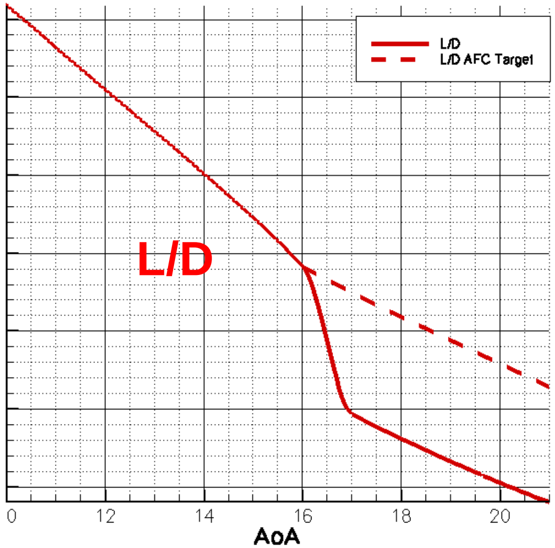




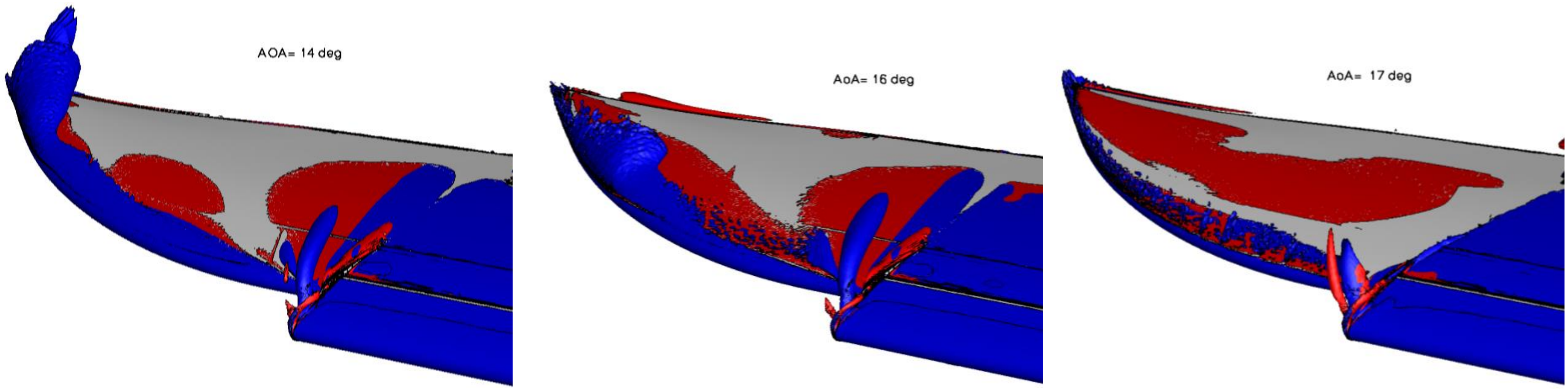
Baseline characterisation

Aerodynamic coefficients on simplified geometry and expected improvement with AFC





Flow topology



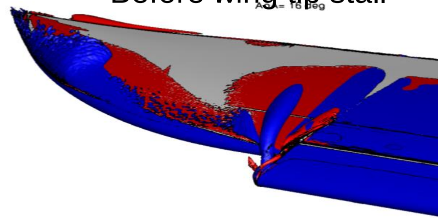
AFC sizing and Workshare

Two identified AFC locations:

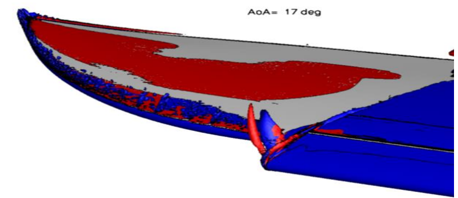
- Separation line at the LE
- Wing tip root region

Workshare

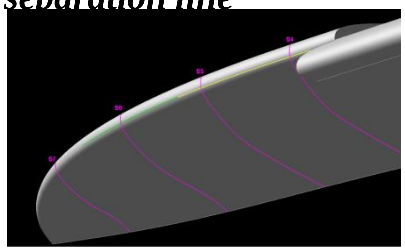
Before wing tip stall



After wing tip stall



LE region:
Between attachment line & separation line

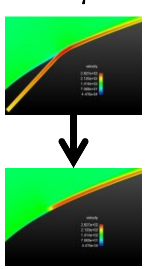


Steady blowing + **SJA**

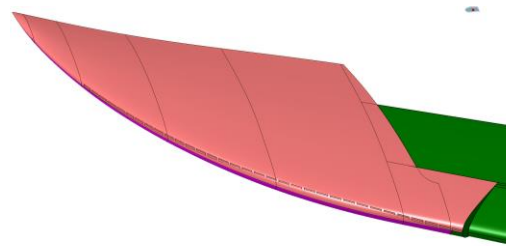
Boundary conditions

Steady blowing + **PJA**

Volume forcing



At the LE separation line:



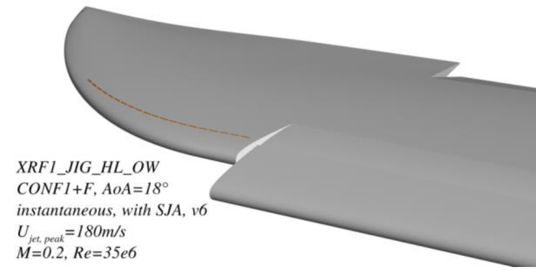
Steady blowing + **SJA**

Boundary conditions

Steady blowing + **PJA**

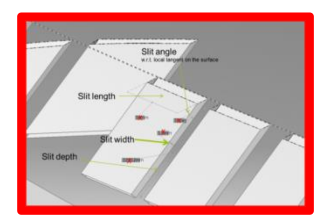
Resolved slots

On the upper surface:
At 10% of chord



Steady blowing + **SJA**

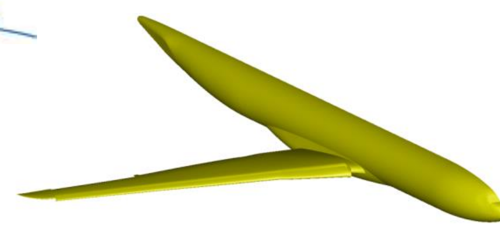
Resolved slots



Transposition at aircraft level:

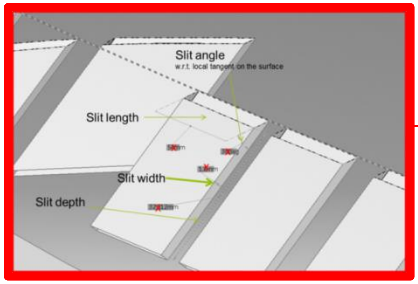
Steady blowing

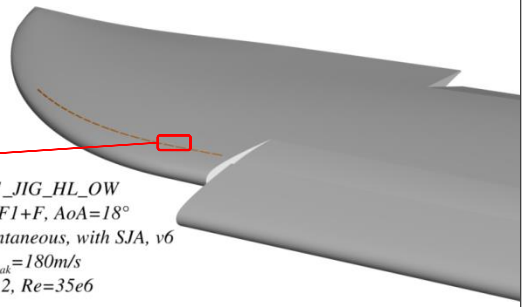
Resolved slots

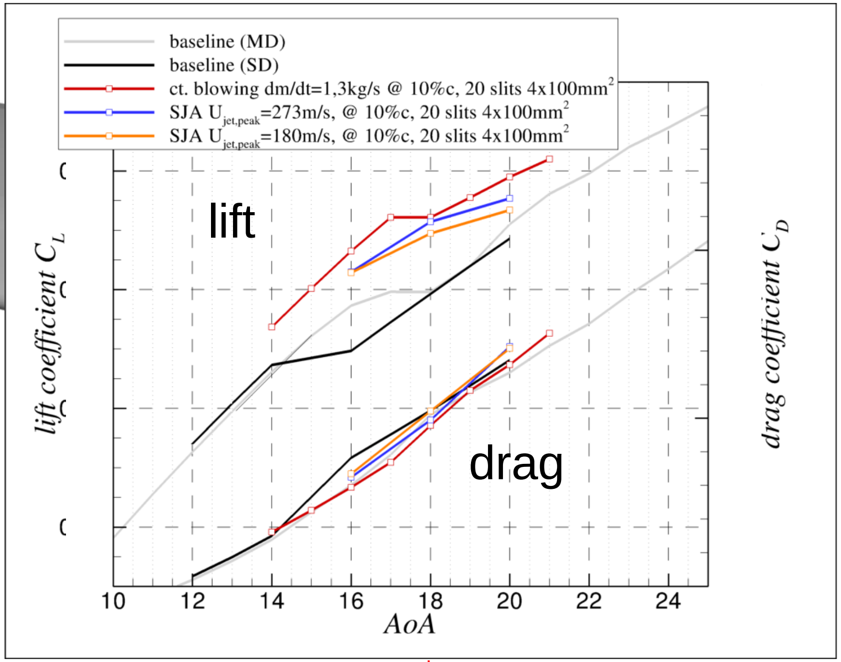


Steady blowing versus Synthetic Jet

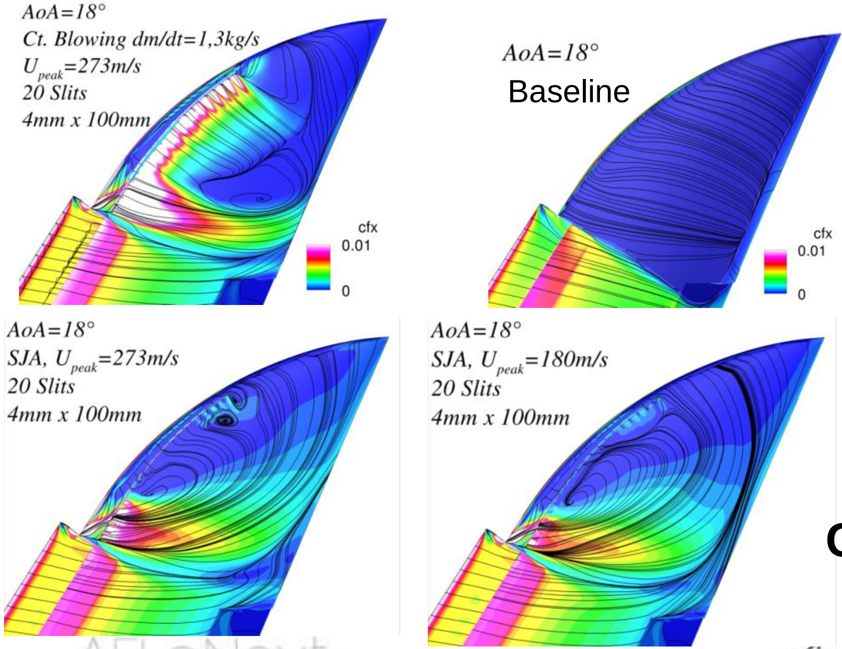
\ **AFC on the upper surface (10% chord) with continuous blowing, Synthetic Jet (sinus or square): 4mm wide slots**



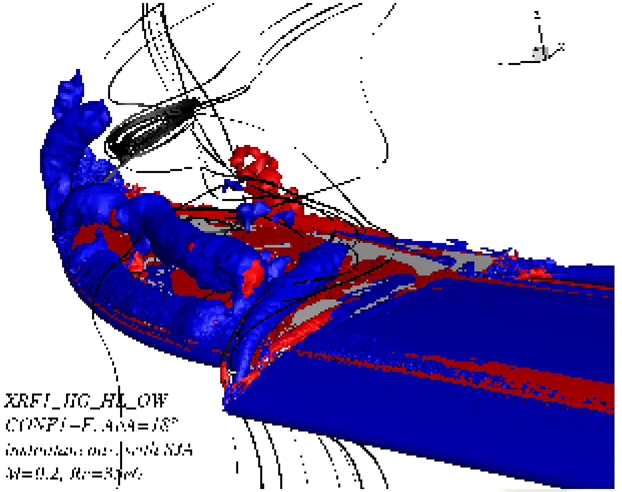




- Steady blowing.Mjet=0.8 (MF=1.3 kg/s)
- Synthetic Jet: max Mjet = 0.8 or 0.5 ; 100 Hz
- Pitch angle to surface = 30°



Cfx



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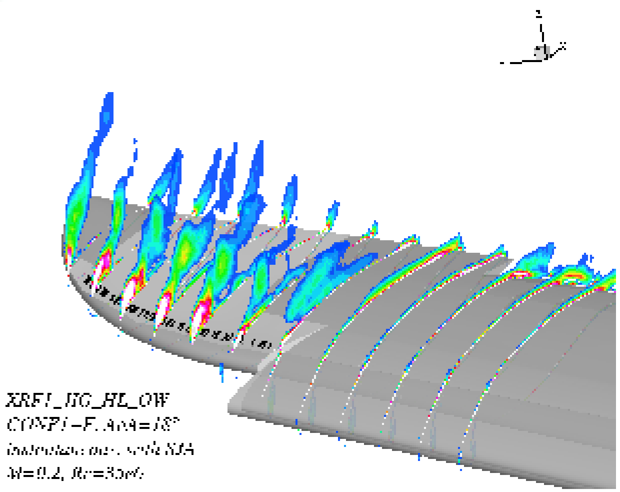
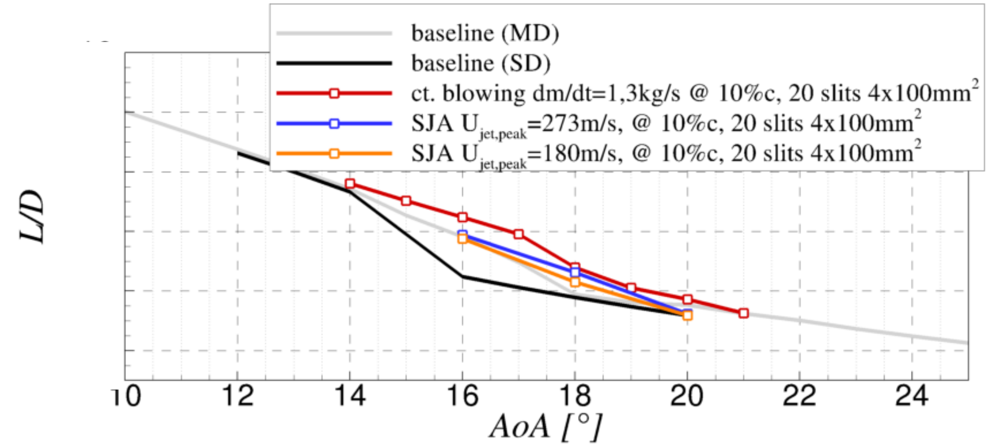
Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

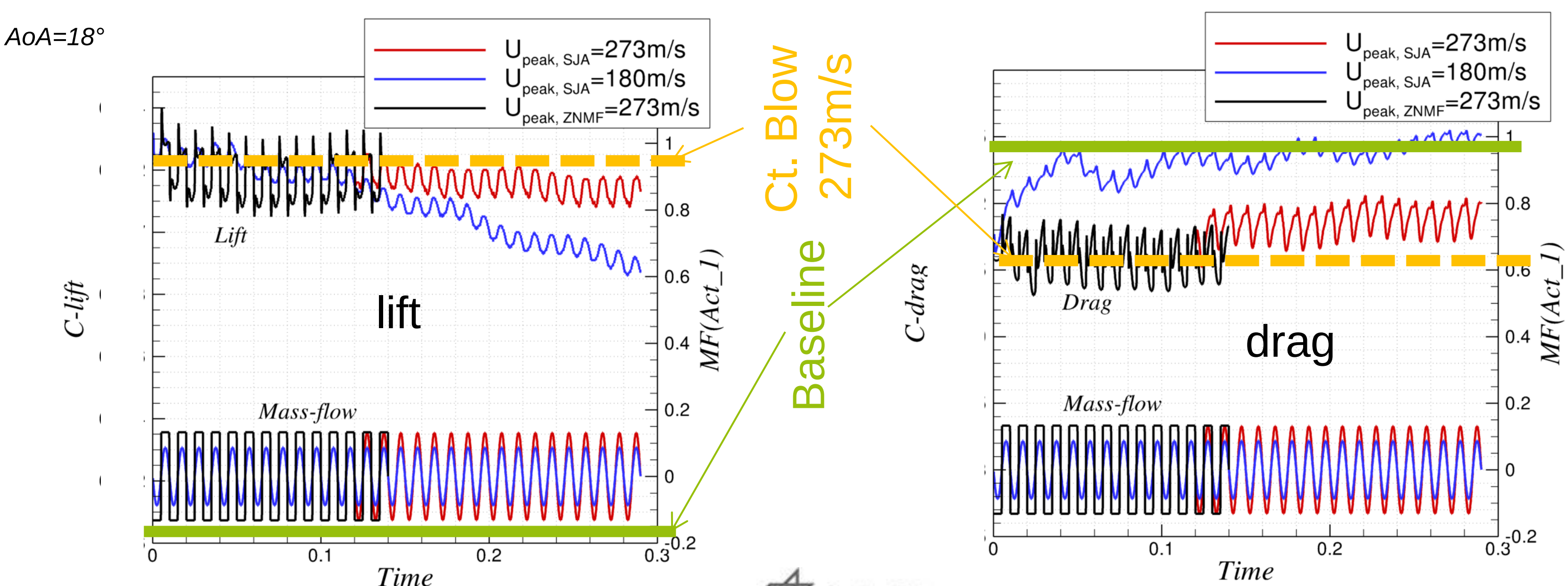
Initial CFD studies with large slots

- AFC on the upper surface (10% chord) with continuous blowing, Synthetic Jet (sinus or square): 4mm wide slots





AoA=18°



Slots taking into account hardware constraints

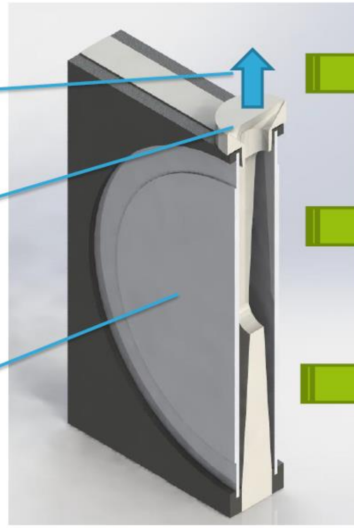
\ Limits due to the hardware technology

First concept studies with slot geometry

Exit velocity:
- Targeted value: 200 m/s

Exit geometry:
- Slot
- 10 x 0.5 mm²

Transducer:
- single or dual transducer concept
- f = 2 kHz



Performance needs to be increased → Change of transducer size

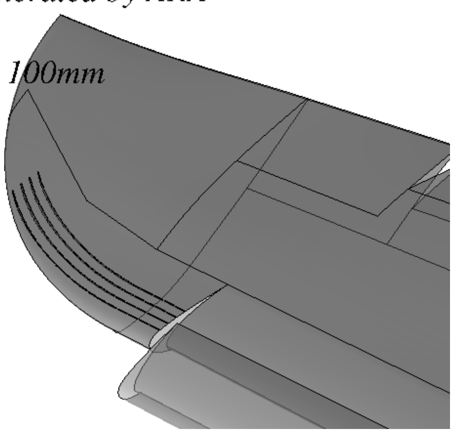
Innovative nozzle design necessary

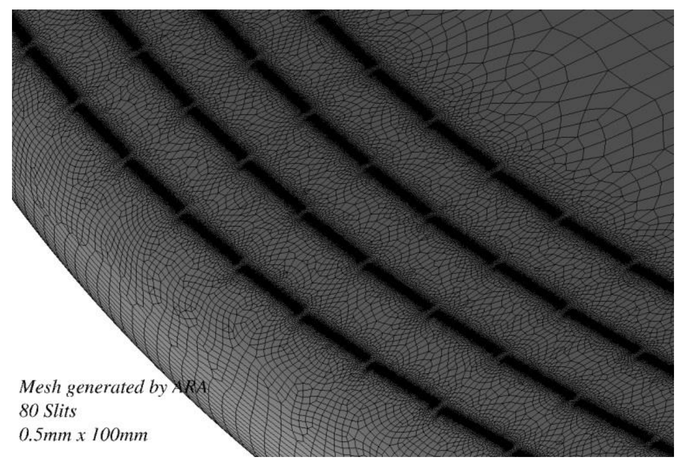
Single transducer concepts for increased robusteness

- To get enough peak velocity, do not exceed 5 mm^2 as slot area
- Typical slot size: 10 mm x 0.5 mm
- Spacing in span:
  - 1mm Synthetic Jet
  - 3mm Pulsed Jet
- Spacing between actuator rows:
  - 50mm Synthetic Jet
  - 30 mm Pulsed Jet

\ AFC on the upper surface:

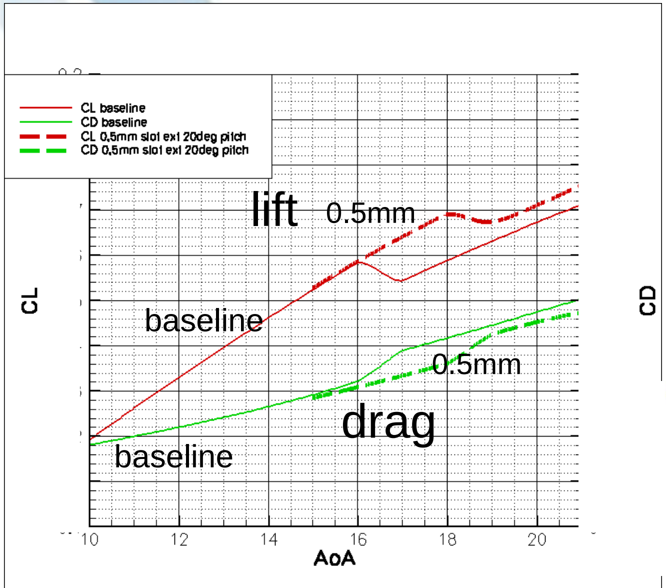
Mesh generated by ARA
80 Slits
0.5mm x 100mm



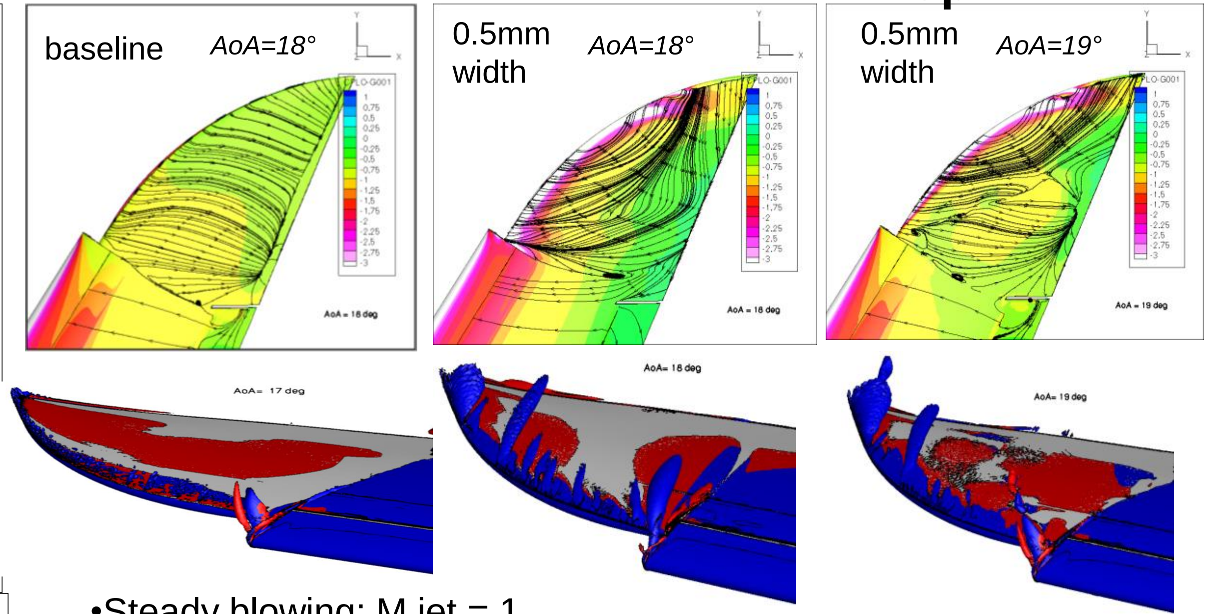


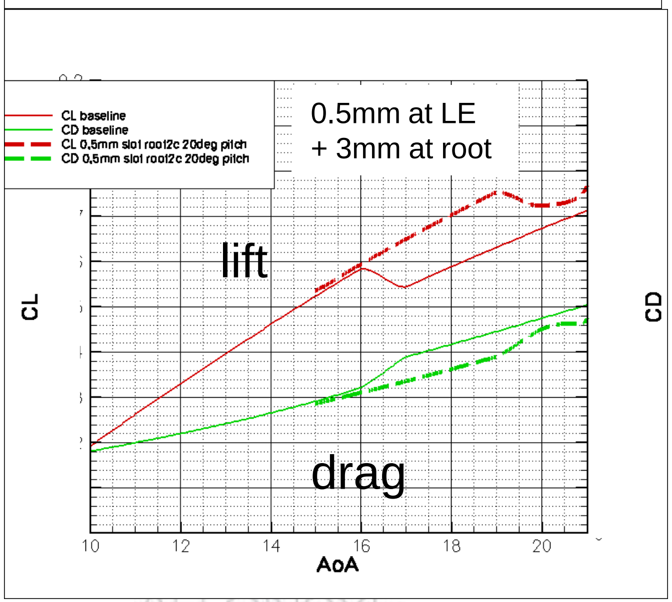
Slots taking into account hardware constraints

\ **AFC at the LE separation line with continuous blowing**



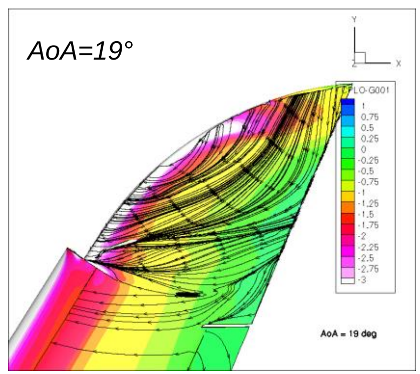
Cp





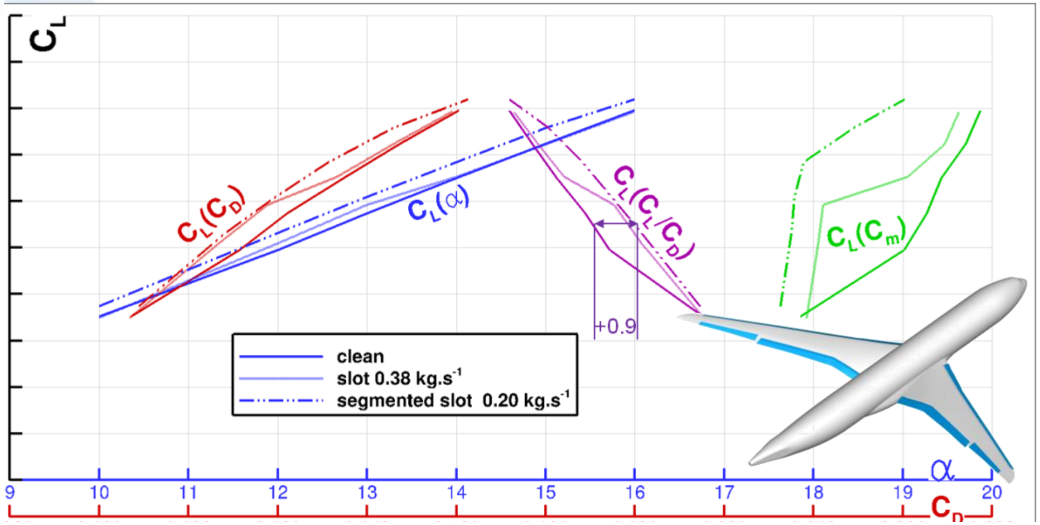
- Steady blowing: M jet = 1
- Pitch angle to surface = 20°

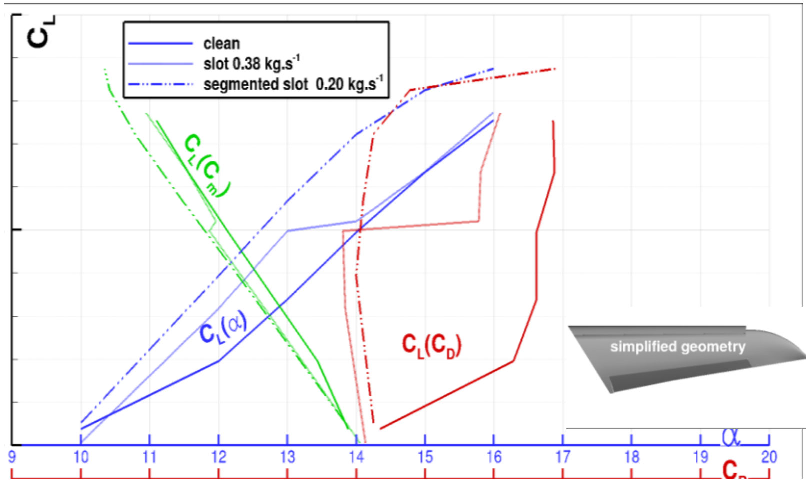
Cp



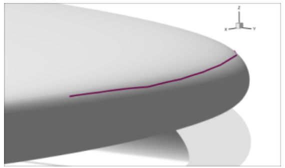
Transposition at aircraft level

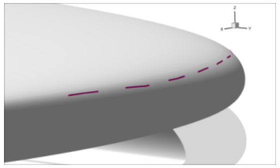
\ **AFC at the LE separation line with steady blowing (200 m/s)**

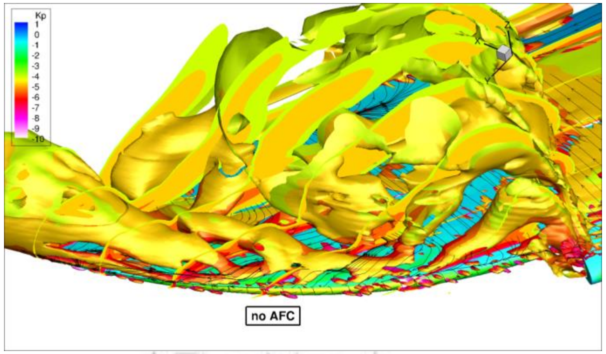


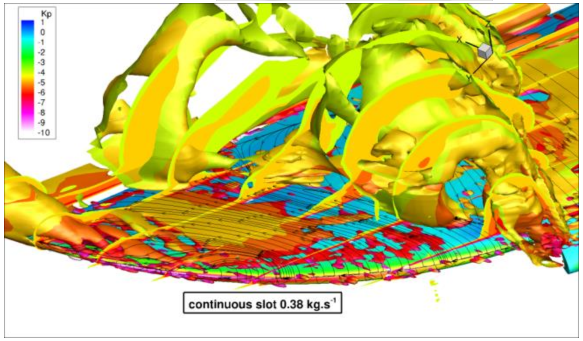


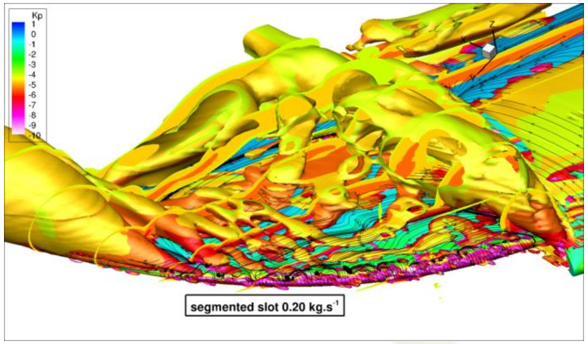
AoA=15°





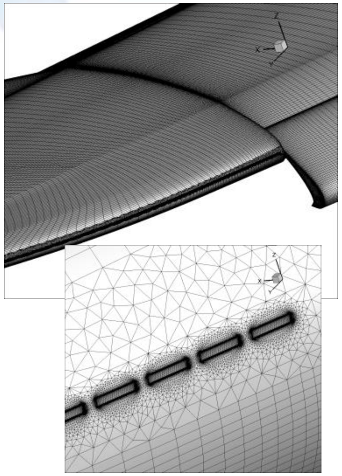




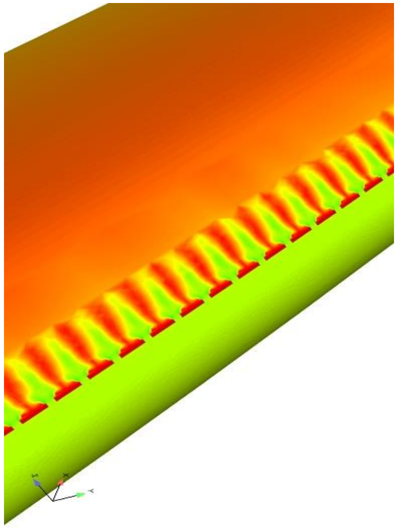


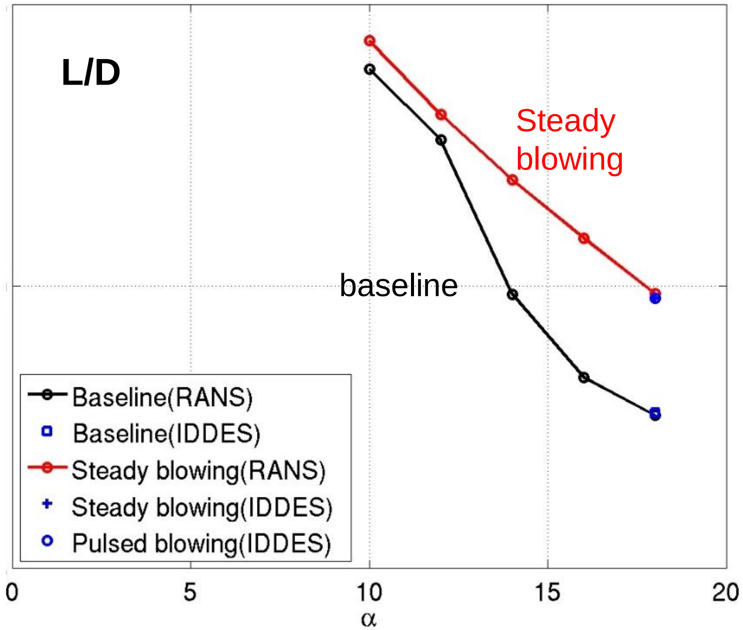
Slots taking into account hardware constraints

\ **AFC at the LE separation line with continuous blowing (300m/s) and pulsed blowing (BAES type)**



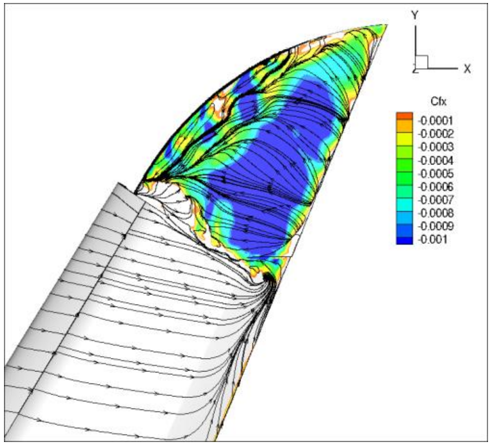
248 PJA at the LE



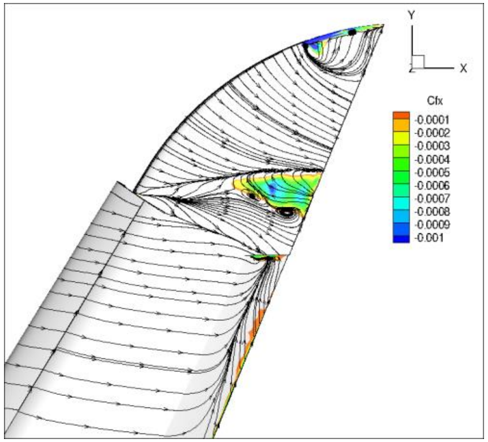


Cfx ***AoA=18°***

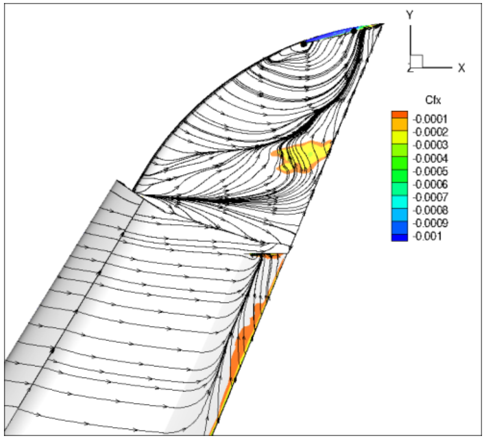
Baseline



Steady blowing

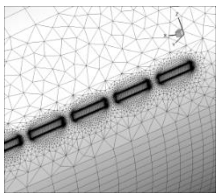


Pulsed blowing (f=50Hz)



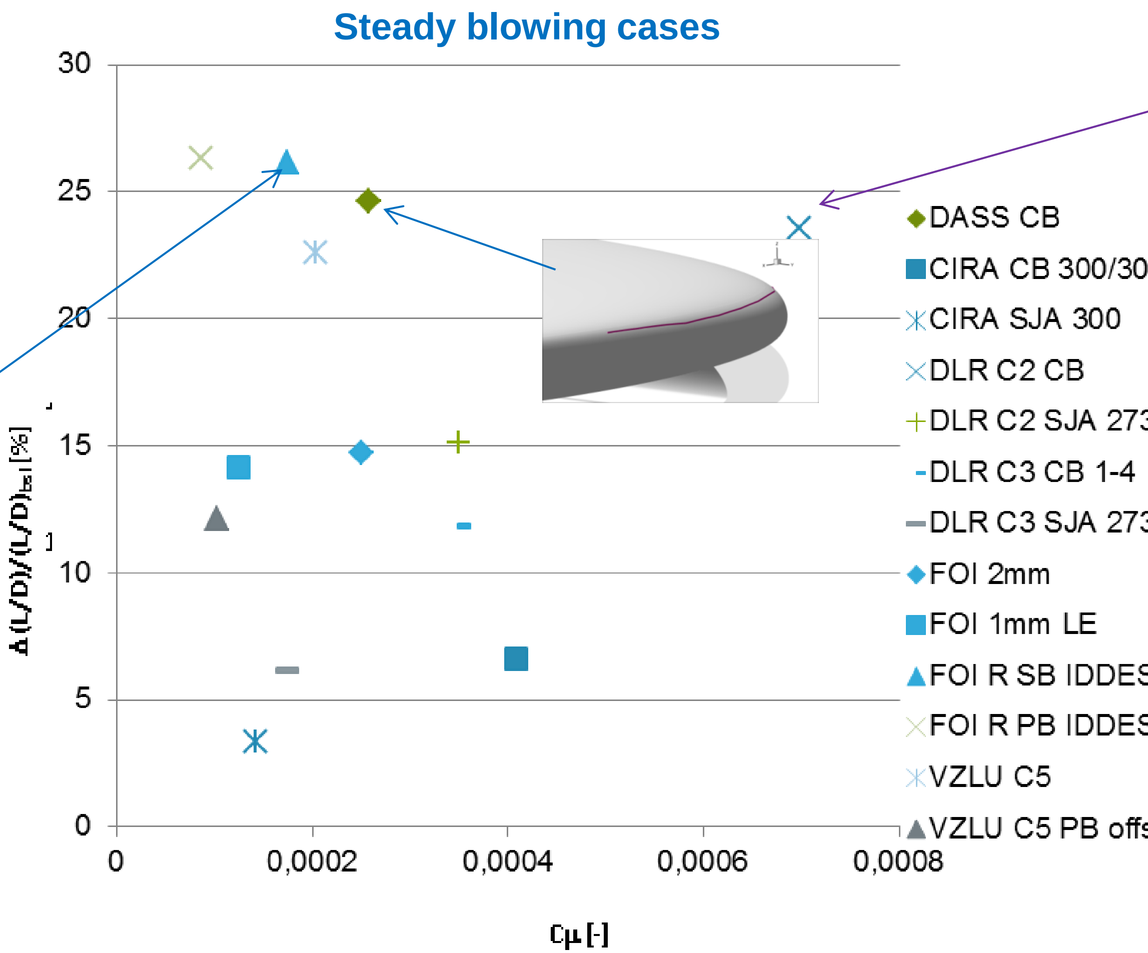
Synthesis of AFC concepts

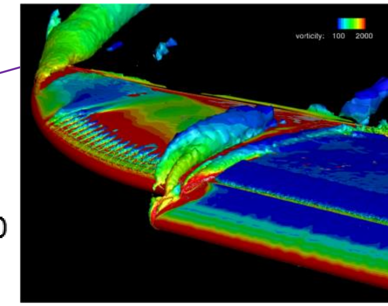
- Evaluation based on % of improvement in L/D at wing tip stall AoA and α range



Steady blowing

AoA range of improvement > 5°

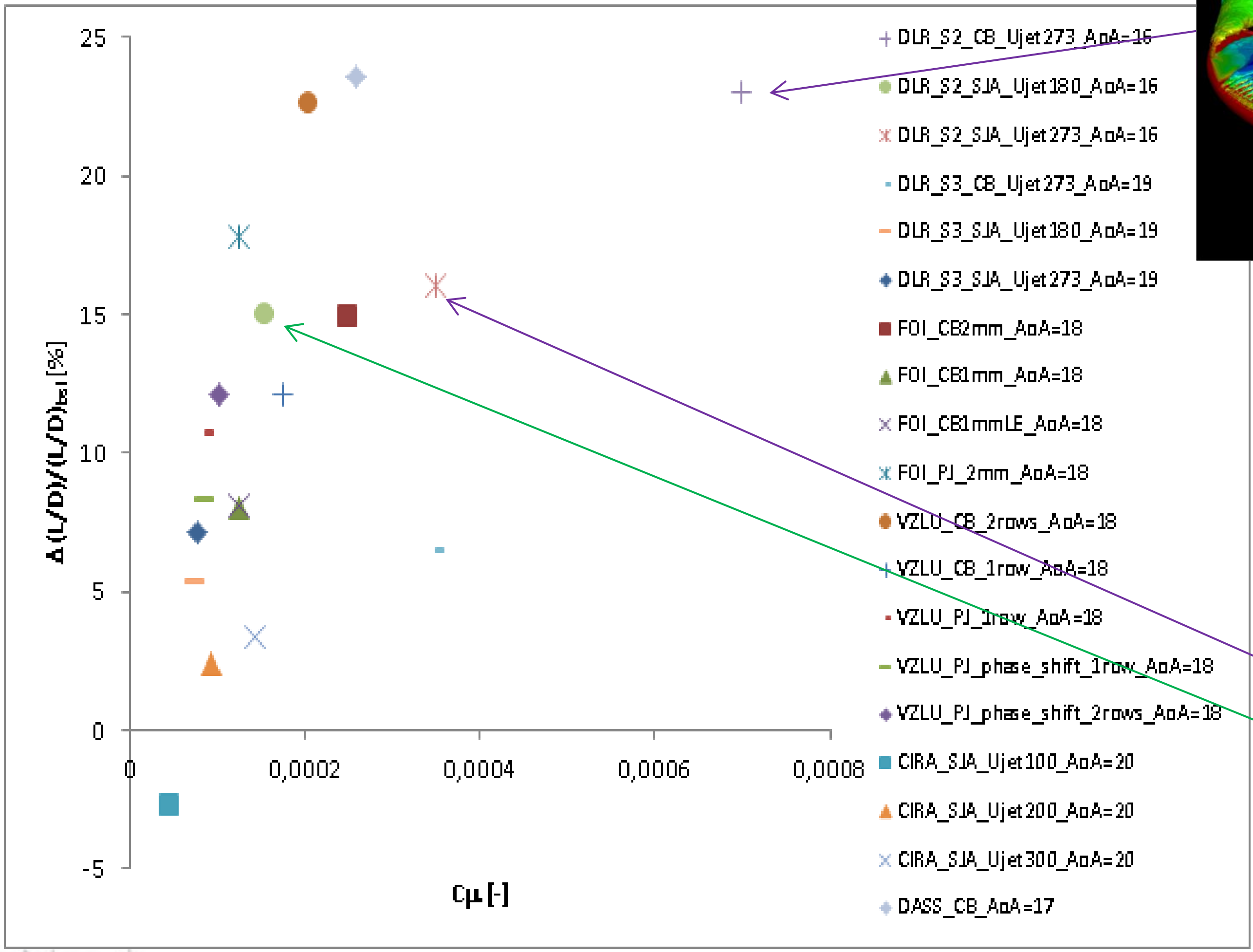


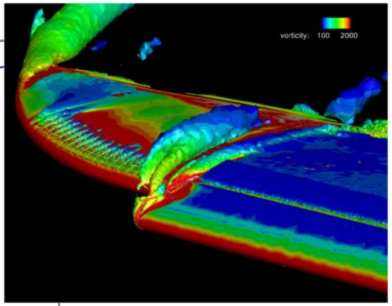


Synthesis of AFC concepts

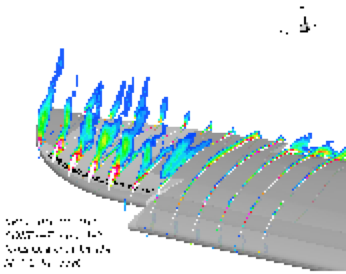
- Evaluation based on % of improvement in L/D at wing tip stall AoA and α range

Effect of Synthetic jet





Steady blowing



Synthetic Jet

V peak = 273m/s

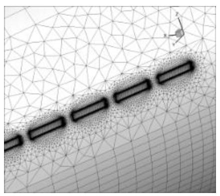
V peak = 180m/s

AoA range of improvement ≈ 3°

Synthesis of AFC concepts

\ Evaluation based on % of improvement in L/D at wing tip stall AoA and α range

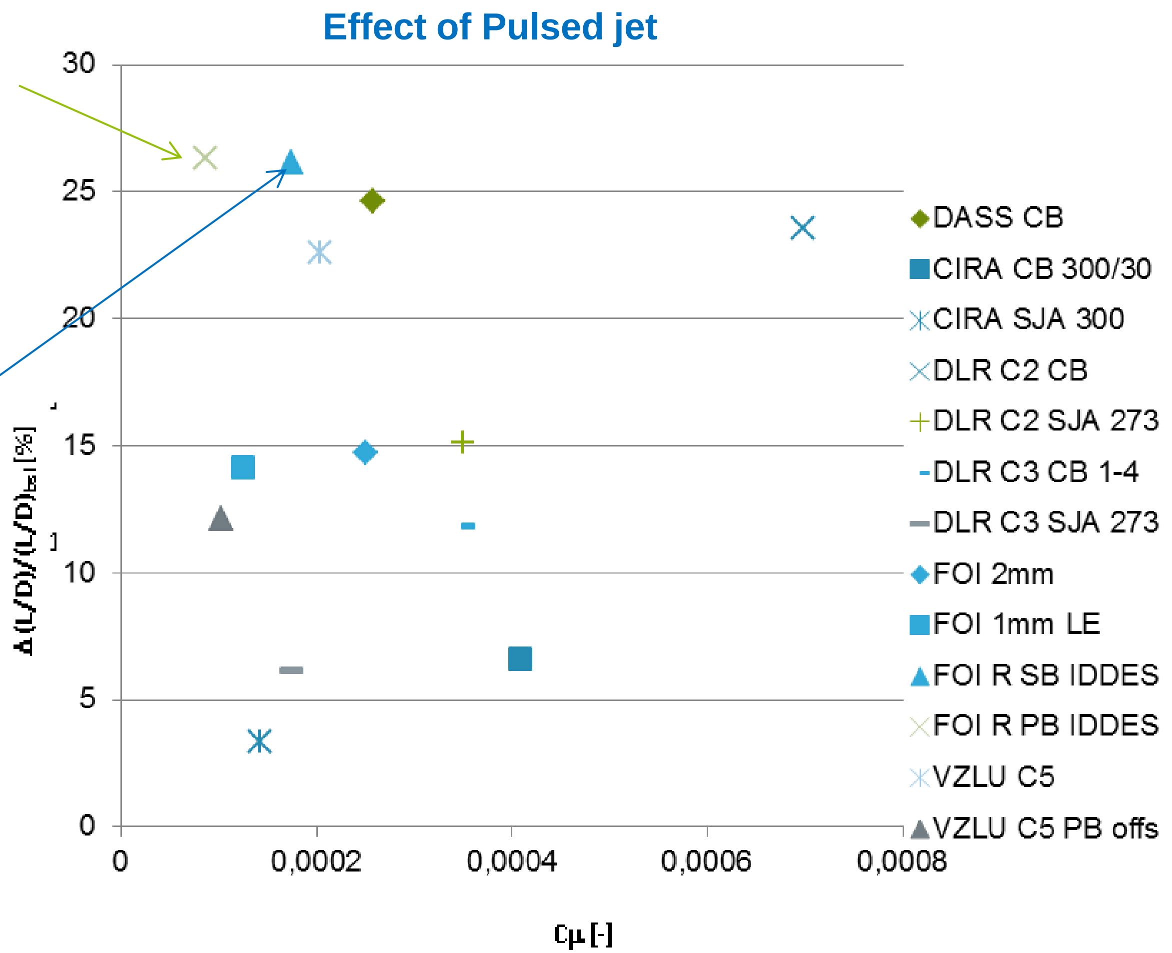
Pulsed blowing
Vp=300m/s 50Hz



Steady blowing

AoA range of
improvement > 5°

Pulsed blowing
With Phase shift:
75% of Pulsed
blowing efficiency



Conclusions

- The potential of AFC to delay flow separation in the outer wing region has been investigated in the AFLoNext project using CFD. The aim was to improve the L/D at Take-off.
- As expected, the best AFC locations were found:
  - Either close to the leading edge separation line to prevent vortices interaction
  - Or at the wing tip root to strengthen the slat end vortex
- Differences in flow mechanisms between steady blowing and Synthetic Jets have been underlined.
- Taking into account sizing constraints coming from Hardware development within the AFLoNext project allowed showing the benefit of segmented thin slots, where longitudinal vortices help stabilising the flow.
- On such a configuration Pulsed Jets were found as efficient as steady blowing for a blowing mass flow divided by a factor 2.
- An overall synthesis was performed in order to extract general trends about best AFC location and actuation type. Updated requirements were also derived to specify the AFC hardware developed within the project.

This project has received funding from the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement No 604013, AFLONEXT project.